

THINKGAME: COOPERATION TO IMPLEMENT CREATIVE THINKING AND GAMIFICATION FOR INNOVATIVE ONLINE TRAINING OF STEM STUDENTS

M. Meneses¹, R. Vilanova¹, A. Cocu², M.J. Varanda Pereira³, S. Dingli⁴, S. F. Mihalache⁵, J. Bernal¹

¹ *Universitat Autònoma Barcelona (SPAIN)*

² *"Dunărea de Jos" University of Galați (ROMANIA)*

³ *Instituto Politecnico de Bragança (PORTUGAL)*

⁴ *University of Malta (MALTA)*

⁵ *Petroleum-Gas University of Ploiești (ROMANIA)*

Abstract

This paper presents the collaborative experience that is under development as the European ERASMUS+ project THINKGAME (Cooperation to implement Creative Thinking and Gamification for innovative online training of STEM students). This project goal emerges from the need to enhance teachers' abilities to incorporate innovative methods in the e-learning systems. The ThinkGame initiative is taking profit of the teaching experience, pedagogical skills and technological competences from all project partners to develop a methodology and proof-of-concept for teachers seeking to create digital educational content that motivates students to develop their creative thinking skills. In this paper, the overall project setup will be presented both from the organisational point of view of the partnership and also presenting the collaborative approach for development and creation of digital educational content that motivates students to develop their creative thinking skills.

Keywords: Gamification, Creative Thinking, STEM

1 INTRODUCTION

Gamification, the application of game design elements in various contexts to evoke experiences reminiscent of games, has remained a popular subject in both industry and academia since its rise to prominence in the early 2010s [1][2]. Particularly, gamification has garnered significant attention within educational settings [3][4]. The practice of gamifying education and learning has a lengthy history (refer to [5]) and it is conceptually understandable given that both game design and learning theories share common psychological foundations [6]. With advancements in technology facilitating the creation of more digitized learning environments and the utilization of technical capabilities developed in the realm of video games to craft immersive and captivating learning experiences, the trend of gamifying education and learning has been steadily on the rise.

The long history and varied ways of incorporating *gameful* interactions to educational contexts has also led to varying terminology for the approach, e.g. serious games, edugames or games for education, game-based learning, and lately, gamification [4][5] and [6]).

Gamification has also emerged as a promising approach in higher education to enhance student engagement, motivation, and learning outcomes. In recent years, educators have increasingly recognized the potential of gamification to transform traditional learning environments into dynamic and interactive spaces that foster active participation and deep learning.

One of the key benefits of gamification in higher education is its ability to make learning more enjoyable and meaningful for students. By incorporating elements such as points, badges, leaderboards, and rewards systems, instructors can create a sense of challenge, progression, and accomplishment that motivates students to actively participate in their learning journey. This can lead to increased student satisfaction and a greater sense of investment in their academic pursuits.

Moreover, gamification can help address common challenges in higher education, such as student disengagement and retention. By leveraging the principles of game design, educators can design learning experiences that are immersive, interactive, and personalized to the needs and interests of individual students. This can result in higher levels of student engagement, improved retention rates, and ultimately, better learning outcomes.

Furthermore, gamification provides opportunities for experiential learning and skill development. By simulating real-world scenarios and providing immediate feedback, gamified learning environments allow students to apply theoretical knowledge in practical contexts and develop critical thinking, problem-solving, and decision-making skills. This can better prepare students for the challenges they will face in their future careers and empower them to become lifelong learners.

However, it's essential to note that effective implementation of gamification in higher education requires careful planning, pedagogical considerations, and alignment with learning objectives. Educators must strike a balance between game elements and academic content, ensuring that gamification enhances learning rather than detracting from it. Additionally, it's crucial to consider issues of equity, accessibility, and diversity to ensure that gamified learning experiences are inclusive and beneficial for all students.

Overall, gamification holds significant potential to revolutionize higher education by creating engaging, immersive, and personalized learning experiences that inspire students to achieve their full potential. As technology continues to evolve and educators explore new ways to harness the power of gamification, its impact on the future of higher education is likely to be profound and far-reaching.

In this paper, the scenario stated under the ERASMUS+ project ThinkGame is presented. In the next section, as a contextualisation of the project thematic, Gamification in Higher Education is succinctly presented highlighting some of the aspects relevant for its application to Higher Education. Section 3 presents ThinkGame as a project with its main motivations and expected contributions. The paper ends by presenting some classification results obtained so far by using academic data provided by the project institutions.

2 GAMIFICATION IN HIGHER EDUCATION

In recent years, most universities use e-learning platforms to deliver courses. Teaching in the form of e-learning is a modern supplement, and sometimes even an alternative to traditional education [7]. Especially since the last few years, with the spread of the Covid-19 crisis, higher education institutions had to shift from traditional teaching to online teaching as an alternative to resume learners' learning [8]. However, over time, these digital environments brought several challenges.

On one hand, in general terms, this distance learning activity has motivated student motivation decreases, resulting in a lack of engagement and participation in courses. On the other hand, instructors struggle to maintain learners' attention, leading to the eventual abandonment of online education systems. To solve this problem and create engaging e-learning platforms, the gamification technique was proposed. Game technologies create opportunities for higher education institutions to redesign and innovate their e-learning models to support learning experiences among learners [9]. However, the higher education context has its own particularities that makes the application of gamification; in fact, this may apply to quite other innovative teaching practices; a real challenge.

Early applied work on gamification of educational settings suggested positive-learning, but mixed results have been obtained [4]. While gamification in general learning systems is known to have a positive impact on student motivation, evidence on its effectiveness in higher education settings is mixed and still uncertain due to the complicated environment in the higher education context. First, the level of difficulty of study is higher at the university than at lower levels of education, and students are more aware of the importance of education they have chosen [10]. Moreover, tertiary education is characterized by the variety of students' profiles, needs and learning methods; thereby, each game element and even each combination of game elements affects each student differently. Given this diversity of features in the higher education context and the increasing number of inter- and multidisciplinary programs, the process of applying gamification is becoming more complex.

The introduction and growing expansion of gamification in education and learning contexts promotes critical reflection on the development of projects that transform students' learning experiences [11]. However, is it that simple to create effective gamified e-learning systems especially in the context of higher education?

3 CREATIVITY IN HIGHER EDUCATION

The importance of creative thinking has been intensified and made prominent by rapid globalisation, increasing competition, technological enhancements [12], and uncertainties and complexities imposed by global phenomena such as the Covid-19 pandemic. Creativity not only leads to societal progress through inventions and discoveries; it also helps society to progress by changing the way people relate to the world, to others, and to themselves, making them more flexible and open to changes [13].

Therefore, higher education institutions need to actively facilitate a supportive environment, resources, and opportunities that enhance creativity; so that it becomes an explicit part of students' higher education experience [14],[15],[16]

Despite the recognition of the benefits of creativity for individuals and their personal achievement as well as for society, except for isolated initiatives in some countries, the development of creativity is not a priority in education. Creative abilities are often repressed not only in elementary and secondary education but also in higher education [17].

According to [18], the importance of creativity in teaching and learning processes has been widely underestimated in the context of higher education, since higher education institutions tend to give more value to critical thinking.

4 THINKGAME

THINKGAME (Cooperation to implement Creative Thinking and Gamification for innovative online training of STEM students) is a European project funded under the ERASMUS+ programme as an Strategic Partnerships for higher education. The partnership includes higher education institutions from Romania, Spain, Portugal and Malta:

- Romania: University Dunarea de Jos, Galati, Petroleum-Gas University of Ploiesti
- Spain: Universitat Autònoma de Barcelona
- Portugal: Instituto Politécnico de Bragança
- Malta: University of Malta

The objective of this project could be stated as to provide a methodology and teaching programs for ITC (Information Technology) related unit courses for improving teachers' competences in using gamification and creative thinking techniques to support them in the development of new learning materials, tools and evaluation methods to enhance the existing e-learning infrastructure used within their own organizations. The interconnection between implemented teaching programs at the consortium level will be based on the European e-Competence framework, which refers to the competencies in the IT professional work context.

4.1 Project motivation

This project arises from different observations that have been shared among partners all relative to engineering students' education. Special attention focused on first years students, those recently enrolled and facing a change of scenario with respect to the one from secondary school. It is true that this gap has always existed. However, the current generation of students who studied during the pandemic also face additional problems, two of them aligned with the thematic of this project and main core of the motivation: On the one hand, access to online content that offers them easy and unconditional solutions to many of the problems of everyday life, which has diminished their ability to think creatively. On the other hand, they no longer have the habit of continuous and sustained training through repetitive learning and work on many practical exercises that would provide them with the deepening of theoretical aspects and the speed in solving problems. By introducing online tools based on creative thinking techniques, the ThinkGame project aims to provide students with the framework in which to develop these much-needed skills.

Another serious problem that affects specially students of the first two years, is that of being at risk of dropping out. All partners are faced with school dropout in the first two years of studies [19], especially because of a low interest of students for the basic subjects that have a high level of abstraction (programming, math). In addition, the students need a stimulative educational process, in order to find

their motivation to work sustained and intensively. These will be realized by incorporation of gamification elements. That's why the project aims to offer students digital tools to motivate them to work, learn and thrive in a highly technological world, to ensure high quality and inclusive education.

On the other hand, there is the teaching experience. When developing its teaching activity, it is important to have the tools and methods to improve teaching quality. Therefore, the quality of learning. It is known that the educational process has good results when learning is student centred. Unfortunately, the lack of teaching staff at the HEI level for ICT fields is a well-known fact, especially since in this field there is a high demand for specialists. The number of the companies with hard-to-fill vacancies for ICT specialists are 90% in Romania, 67% Malta, 47% Portugal, 27% Spain (source Eurostat). The project will offer, through the innovative tools included in the existing e-learning platforms, an individualized learning path for each student, corresponding to their level of knowledge, with high flexibility in accessing them. These tools will not replace classical education, they will extend the resources offered to students.

4.2 Project contributions

ThinkGame has been conceived and designed to have impact at Higher Education level, from the institutional-systemic level to teacher-learner level. ThinkGame will represent a suitable scenario to allow participating institutions to gain experience in international cooperation and to strengthen their capacities, but also to produce high-quality innovative deliverables. Teachers from the 5 participating organizations will collaborate to identify the most suitable gamification elements and creative thinking techniques that can be integrated into the online tools for STEM students, based on their experience in these fields. As part of the exchange and collaborative experience, partners will make use of available resource sin their institutional Learning Management systems, highlighting functionalities instead of implementations. This will allow better exchange of experiences trying to make them independent of the specific Learning Management Platform. The courses they will modernize within the project will be cross-use in partnership, the goal being to obtain high-quality deliverables after a practical test in 2 academic years. The reuse of the online educational content will be possible by using the ICT e-Competence framework for monitoring learning results and by using Learning Management Systems standards for content implementation.

ThinkGame will also contribute to generate and stimulate innovative learning and teaching practices. ThinkGame will provide HEI teachers with a methodology and a proof-of-concept helping them to introduce elements of gamification and creative thinking to innovate the online resources ICT (Information and Communication Technology) students. These resources will be integrated into the existing e-learning platforms. Innovative tools developed in the project that implement gamification elements will increase students' motivation and interest to practice subjects with a high degree of abstraction, and didactic methods that will stimulate creative thinking will help them quickly adapt to technological progress. Gamification is known to increase students' involvement and to motivate them to ensure learning.

As selected course units are related to first courses on engineering degrees, and focused on ICT, the project will definitively impact on the development of STEM in higher education. Those course units, being first years, are part of the curriculum for students in ICT engineering specializations. The content of these courses does have a high degree of abstraction therefore the students need a lot of practice to understand and apply the theoretical notions.

The tools developed during the project, either methodological and based on current online tools at common Learning Management Systems, can become powerful tools for creative thinking and stimulating perseverance through gamification elements. It can help teachers to create and share digital content, being assistive by ensuring accessible digital content, thus addressing unequal access due to socio-economic grounds.

5 FIRST STEPS

During these first months of the project, the consortium started by selecting curricular engineering subjects related to ICT. Those subjects will be unit courses where Gamification methodologies will be applied. Main idea is to generate digital resources in such a way that can be later applied in other

institutions. First looking for a multiplier effect within the project partner institutions and, on a second step, once the project is finished, looking for a potential application on institutions from outside the project. To achieve this, the methodologies should be properly described and documented. Also, the Learning Management Systems functionalities and associated tools be made available to easy its implementation to teachers that are not fully familiar with.

The subjects under study are the following ones:

- | | |
|--|----------------------|
| • Object oriented programming - Java | 2 nd Year |
| • Foundations of AI | 1 st Year |
| • Computer programming and programming languages - C | 1 st Year |
| • Imperative Programming - C | 1 st Year |
| • Mathematics Applied to Engineering (1st year) | 1 st Year |

The Gamification methodologies that are to be developed for those subjects will be linked to their Learning Outcomes. This will facilitate posterior evaluation of the gamification. The application of the creativity and gamification tools will be applied corresponding to the following logic.

- a) The partners responsible for the initial development of the creativity and gamification tools will apply them on the corresponding course from the above list.
- b) This first application will have as a result improved curricular methodology results.
- c) After this first application, a critical evaluation will be concurred in order to improve the methods, digital online tools, implementation into the LMS, easy their application, etc
- d) There will be a second implementation of the creative thinking and gamification approaches. This will take place during the third year of the project. In this second implementation the improved courses will be held twice, once by the partner who developed them and second, by another partner who has the same course.
- e) Final comparative analysis will be conducted, improvement on the results and impressions got by the students, etc

As final output by the project, all this will be collected and reflected on a report with key takeaway, efficacy, hints, which can be disseminated at the level of the own universities, but also at the European level, through conferences, workshops, and collaborators.

6 CONCLUSIONS

This communication has presented the ThinkGame SPEET ERASMUS+ project. The project has just started. The paper introduced the important aspects of Gamification and creative thinking specially within Higher Education. ThinkGame project has being described from its partnership composition. Motivation for the application of Gamification and new teaching learning methods, at the first years of engineering subjects is introduced and the need to improve the teachers' tools and resources to deal with student engagement has been also presented. Finally, some first preliminary steps that are being conducted have also being presented.

ACKNOWLEDGEMENTS

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

REFERENCES

- [1] Huotari, K., & Hamari, J. (2017). A definition for gamification: Anchoring gamification in the service marketing literature. *Electronic Markets*, 27(1), 21–31.

- [2] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining gamification. In Proceedings of the 15th international academic MindTrek conference, Tampere, Finland, September 28–30, pp. 9–15.
- [3] Koivisto, J., & Hamari, J. (2017). The Rise of Motivational Information Systems: A Review of Gamification Research. *International Journal of Information Management*, Volume 45, 2019, Pages 191-210,
- [4] Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74, 14–31.
- [5] Deterding, S. (2014). The ambiguity of games: Histories and discourses of a gameful world. In S. P. Walz & S. Deterding (eds.), *The Gameful World: Approaches, Issues, Applications* (pp. 23–64). Cambridge, MA: MIT Press.
- [6] Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming*, 45(6), 752–768.
- [7] Górska, D. (2016). E-learning in Higher Education. The Person and the Challenges. *the Journal of Theology, Education, Canon Law and Social Studies Inspired by Pope John Paul II*, 6(2), 35.
- [8] Sofiadin, A., & Azuddin, M. (2021). An initial sustainable e-learning and gamification framework for higher education. In *International conferences on mobile learning 2021 and educational technologies 2021*.
- [9] Alhammad, M. M., & Moreno, A. M. (2018). Gamification in software engineering education: A systematic mapping. *Journal of Systems and Software*, 141, 131–150
- [10] Urh, M., Vukovic, G., et al. (2015). The model for introduction of gamification into E-learning in higher education. *Procedia - Social and Behavioral Sciences*, 197, 388–397.
- [11] Garone, P., & Nesteriuk, S. (2019). *Gamification and learning: A comparative study of design frameworks*. Springer.
- [12] Alencar, Eunice M. L. S. E., Danise Fleith, and Nielsen Pereira. 2016. "Creativity in Higher Education: Challenges and Facilitating Factors." *Trends in Psychology* 25 (2): 553–61.
- [13] Glaveanu, Vlad Petre, Michael Hanchett Hanson, John Baer, Baptiste Barbot, Edward P. Clapp, Giovanni Emanuele Corazza, Beth Hennessey, et al. 2020. "Advancing Creativity Theory and Research: A Socio-Cultural Manifesto." *The Journal of Creative Behavior* 54 (3): 741
- [14] Hannon, S., H. McBride, and B. Burns. 2004. "Developing Creative and Critical Thinking Abilities in Business Graduates: The Value of Experiential Learning Techniques." *Industry and Higher Education* 18 (2): 95–100
- [15] Ungaretti, Toni, Peter Chomowicz, Bernard J. Canniffe, Blair Johnson, Edward Weiss, Kaitlin Dunn, and Claire Cropper. 2009. "Business + Design: Exploring a Competitive Edge for Business Thinking." *SAM Advanced Management Journal* (07497075) 74 (3): 4–43
- [16] Vincent-Lancrin, Stéphan, Carlos González-Sancho, Mathias Bouckaert, Federico de Luca, Meritxell Fernández-Barrerra, Gwénaél Jacotin, Joaquin Urgel, and Quentin Vidal. 2019. *Fostering Students' Creativity and Critical Thinking: What It Means in School*. Paris: OCDE Publishing.
- [17] Wechsler, S. M., & Nakano, T. C. (Eds.). (2011). *Creativity in the higher education: An international perspective*. São Paulo, SP: Vetor.
- [18] Jackson, N. (2007). Imagining a different world. In N. Jackson, M. Oliver, M. Shaw, & J. Wisdom (Eds.), *Developing creativity in higher education* (pp. 1-19). London: Routledge.
- [19] M. A. Prada, M. Dominguez, J.L. Vicario, P. Alves, M. Barbu, M. Podpora, U. Spagnolini, M.J. Varanda, R. Vilanova, "Educational Data Mining for Tutoring Support in Higher Education: A Web-Based Tool Case Study in Engineering Degrees," in *IEEE Access*, vol. 8, pp. 212818-212836, 2020